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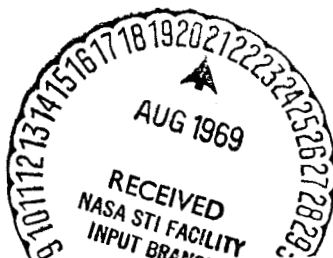
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Mission Planning
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ABSTRACT

An earth looking experiment facility which is carried on a large manned earth orbital space station is described. The orbital operation of the facility is categorized in terms of modes. The properties of the modes and transitions between the modes are described. The control of the facility is primarily automatic. Provision is made for man to function as an observer and as an experimenter. Man's primary role is to keep the automatic facility in optimum operating condition.



(NASA-CR-103959) EARTH LOOKING SUBSEQUENCE
/DESCRIPTION AND OPERATION/ IN A
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SUBJECT: Earth Looking Subsequence (Description and Operation) in a Multi-Disciplinary Earth Orbital Space Station - Case 720 DATE: December 27, 1968
FROM: W.W. Elam

TECHNICAL MEMORANDUM

I. INTRODUCTION

This memorandum describes an earth looking experiment facility and its operation. This earth looking experiment facility is a major element of a multi-disciplinary earth orbital space station. This memorandum is one of a number of memoranda dealing with specific scientific disciplines which the space station will support. For an overview and basic rationale of the space station the reader is referred to Reference 1. The sequence of operations of the earth looking instruments given here are in accord with the mission sequence plan described in Reference 2.

II. DISCIPLINARY OBJECTIVES OF THE EARTH LOOKING FACILITY

The objective of the facility is to utilize an instrument platform for earth sensing instruments which has very important, unique, and novel advantages of perspective, coverage, and endurance in observing the earth (lithosphere, hydrosphere, atmosphere) for scientific and applied scientific purposes. The observations of the earth will be used to increase our knowledge of the natural and cultural environment of man and to use that increased knowledge for our practical benefits.

In most cases, the requests for data by the Principal Investigators or operating agencies will be for data on specific targets under specific conditions of illumination, etc. The implementation of these requests is largely handled by automated scheduling. Man is used to improve the performance of the instruments by performing the functions of calibration, operation, maintenance, and repair. Man also contributes as an optional link in the control system and as an observer performing more exploratory observations.

III. HARDWARE

- a. Description: Fourteen to twenty instruments will make up the earth looking experiment system. Imagers and spectrometers/radiometers (passive and active) operating in the ultra-violet, visible light, near infrared, thermal infrared, and microwave regions of the electromagnetic spectrum are included. These instruments are

mounted in most instances to look in the nadir direction. There are requirements in some instances to "look" at space for reference or calibration purposes. Also, the atmospheric density radio occultation experiment transmits and receives energy to and from a slave satellite tangentially through the earth's atmosphere.

Within each sensing method listed above, for example infrared spectrometry, one or more instruments can be considered. For sensing the earth surface high spatial resolution infrared spectrometers operating in the atmospheric window spectral regions are required. For atmospheric sensing, infrared spectrometers operate with grosser spatial resolution in the emission/absorption bands of the atmospheric constituents of interest. Also in atmospheric sensing, advantages are gained by having both narrow field of view and wide field of view spectrometers operating in the same spectral band.

- b. Support by Space Station: The physical characteristics of the payload can only be approximated at this time. The earth looking facility considered here is of the same general type and size as the large earth looking facilities described in Refs. 3 and 4. The weight of the earth looking subsystem, not including special support, data handling, displays, control systems, will be from 1000-2000 lbs. The volume will be 75-200 cu. ft. Electric power required may be as little as 1500 watts (night side) or as much as 3000 watts (day side). Cryogenic cooling of some of the detectors will be required. The type of cooling will depend upon "state of the art" in the mid-70's. It is estimated 3-8 lbs of coolant (liquid nitrogen or other) per day will be required. The experiments will be mounted on a platform 100-125 sq. ft. in area exposed to the nadir direction with one axis along the ground velocity vector. There must be a capability of holding this position independent of space station motion. (pointing accuracies $<0.5^\circ$ all axes, rates $<0.03^\circ/\text{sec}$ all axes.).
- c. Data Generation and Return: The magnitude of the data handling requirement depends strongly on the extent to which the data is used for operational purposes by meteorological or earth resources agencies. If the mission has no such operational purpose, i.e., is research oriented only, the bulk of the data can be stored on film or tape and be physically returned with crew relief. Only targeting and data for quick look analysis need be returned in near real time. If there are operational objectives, then some data must be returned in near real-time, some daily and most within a week. Because much rather high resolution imagery is

Involved, the bit rate for telemetry could be very high (2×10^6 b/s). Alternative to telemetry, returning hard copies of this imagery in a time scale to meet operational requirements is costly, although automated return procedures are successfully practiced by the Department of Defense.

The total amount of data produced depends to a considerable extent on the state of development of the sensing techniques and of data utilization techniques at the time of the mission, as well as the extent to which the data will be used for operational purposes. A minimum mission should provide data equivalent to about 100 lbs. of film per quarter which for the high data rate instruments (imagers) could be accomplished in 4 weeks total time. A maximum mission should provide data equivalent to about 300 lbs. of film per quarter.

- d. Experiment Modes: The operation of the earth looking facility is described in terms of modes. The operating modes are "automatic" and "manual". The non-operating modes are "inactive", "ready", "calibrate", "service", and "repair". The properties of these modes are shown in Figure 1.

The earth looking facility includes many instruments. As noted below, the component instruments are operated in combinations required by the scheduled sensing tasks. Each instrument is controlled according to program by the on-board computer. The modes, then, grossly describe the status of the package; individual instruments may be in a different mode at a particular time.

- (1) Operating modes: The principal means of controlling the operation of the instruments is by means of the on-board computer (OBC). This on-board computer should have two way communication with an experiment control computer at MCC, and thence with the principal investigator.

The exercise of the instruments in various combinations according to the disciplines served and areas to be sensed is programmed according to mission time. Targetting and constraint data are provided by the Principal Investigators, partially in the initial proposal and partially (as permitted by the computer program) in near real time. Sun angle requirements are included in the program. The scheduling of combinations of instruments and the recording the status of the amount of scheduled sensing accomplished and updating the schedule is a complex operation, amenable to computer control. Because the

Instruments, except microwave instruments, are subject to cloud interference a cloud presence detector (sensitivity level dependent upon sun angle) will be incorporated to give a "no sensing" signal if clouds are present. The fact that sensing was not done must be reported to the control computer on board and to the master control computer at MCC to update future sensing plans.

The secondary means of experiment operation and control is the manual mode. An astronaut is present in the facility. To the desired degree, he takes control from the computer of target selection and instrument selection. Repair, calibration, and service of individual instruments is accomplished in this mode. Time is allotted during each shift to use this mode, although it would be more desirable to have flexibility in the schedule in order that manual control would be used over promising target areas. The manual mode permits exploratory, target-of-opportunity studies. It would be scheduled a greater fraction of the time when an earth scientist was in residence on the space station. Also in event of failure of the automated control system a fully manual mode could be used as a contingency mode.

- (2) Non-operating experiment modes: Inactive mode - In this mode the system or its components are in operable condition but in power off or minimum power condition. This mode will usually precede the ready mode. It will always follow the repair or service mode, if only briefly.

Ready mode - This mode is essentially a warm up mode. Scheduled experiments are brought on line by the on-board computer. In this mode housekeeping signals are checked against standards by the "automatic on board system monitor" (AOBSM), thus a calibration check is included. If AOBSM indicates out-of-calibration, it is switched to calibrate mode. If the calibration checks are within limits the switch would be to automatic or manual operating modes.

Calibrate - Upon out-of-calibration indication from the AOBSM or based on analysis of sample data by the P.I., calibration will be performed manually by a crewman. If calibration cannot be accomplished, a switch to service or repair mode will be made. If calibration can be accomplished, control will be returned to the onboard computer. Routine calibration will also be done.

Service mode - In this mode the equipment is available for crew services including film change, routine maintenance, experiment modification or alteration, and change of experiments. Switch will always be to the inactive mode (normally under OBC control). A major deactivation of the earth looking facility is involved.

Repair mode - If calibration cannot be accomplished or if the AOBSM indicates another malfunction, a switch is made to the repair mode. Repair will be accomplished on-board by the crew assisted by technical consultation with MCC. If repair can be accomplished, a switch is made to inactive mode (normally under OBC control). A major deactivation of the earth looking facility is involved.

(4) Constraints and Assumptions

a. Command, control:

Command for instrument operation is primarily on the ground at the mission control center with capability for manual override by the astronaut for safety or emergency reasons.

Control is primarily by the on-board computer which, in turn, is controlled by a two way link with a computer in Mission Control Center. Their link may be intermittent; maximum "no contact" time on the order of 3-5 hours.

b. Data system:

Undetermined - depends upon general status of remote sensing at time of flight as such status affects the need for data for operational use. Early flight and relatively little advance in the status of remote sensing would call for most data being recorded on film or tape and physically returned with astronauts. A more advanced status would call for a high data rate telemetry system. The latter is assumed in Reference (2).

c. Crew:

Most important skill is that of instrument calibration, maintenance, and repair. These provide data assurance. Skill as an accomplished observer of geophysical phenomena is highly desirable; an astronaut with such training should be flown on one or more logistics cycles.

d. Logistics:

Capability to bring up 300-500 lbs. of new film and instrument spares and alterations, and return of at least 200-300 lbs. of film per resupply mission.

e. Configuration:

Instruments oriented in the nadir direction with one other axis in the direction of the ground velocity vector. Capability to hold orientation within $.05^\circ$. Instruments accessible to repair and alteration in shirt sleeve environment.

5. Contingencies: Although the operation of the facility is preplanned with provision in the capability of the control system to update the plan, there are variations in the targets sensed, in the performance of man-instrument system, and also in the performance of instrument support system which should be capable of being accommodated to insure optimum return. These variations include:

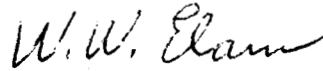
- a. a capability to update the system in the light of new knowledge gained about the earth;
- b. the use of improved or modified sensors;
- c. optimizing the use of the peculiar skills of the crew (the manned mode would be used more when there is a trained geoscientist aboard);
- d. changing the control program or using the manned mode in order to optimally observe short lived phenomena such as storms and storm effects, floods, volcanoes, earthquakes, acute air pollution situations, etc.;
- e. and to overcome inadequacies or failures in the instruments and instrument support systems such as defects in the stored control program or the AOBSM, defects in the instruments, and defects in the instrument platform control.

The implications of these variations in the design will be treated in a later memorandum.

SUMMARY

A earth looking facility on a large manned earth orbital space station and its orbital operations have been described. The primary means of control and scheduling of the components of the facility is by automated control. This is required in part by the complexity of the scheduling and in part by the long duration operations.

Provision is made for man as an experimenter and as an observer, although primary reliance for meeting disciplinary objectives is placed in the automated system. Man is expected to play an essential role in keeping the automated system in optimum condition.



W.W. Elam

1011-WWE-b1

Attachment
Figure 1

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REFERENCES

1. "Introduction to a Study of Operations on a Multi-Disciplinary Space Station, G.T. Orrok, Bellcomm TM-68-1011-11, December 27, 1968.
2. "Mission Sequence Plan for a Multi-Disciplinary Earth Orbital Space Station - A Preliminary Report," S.L. Penn, Bellcomm TM-68-1011-9, December 27, 1968.
3. Saturn V Workshop Study, Volume II - Task Team Analysis, OMSF Planning Group, April 1, 1968.
4. Experiment Program for Manned Orbital Workshops (DRAFT), Payloads Directorate, Advanced Manned Mission Program, Office of Manned Space Flight, August 14, 1968.

FIGURE 1— EARTH LOOKING EXPERIMENTS SUBSEQUENCE

| PROPERTIES | | MODES | | READY | AUTOMATIC | MANUAL | CALIBRATE | INACTIVE | SERVICE | REPAIR |
|--|--|---|---|---|--|---|---|--|---------|--------|
| I TIME: a) DURATION, REPETITIONS, USE OF CREW b) CONSTRAINTS | | a) 10-30 MIN., EACH EVENT; REPEATED BEFORE EACH OBSERVATION SEQUENCE b) NONE | a) 20-90% OF MISSION TIME DEPENDING ON INSTRUMENTS (SOME INSTRUMENTS, 90%, SOME 20%) b) ATMOSPHERIC CONDITIONS AND LOCATION IN ORBIT WILL DETERMINE OPERATING INSTRUMENTS | a) < 5% OF MISSION TIME IRREGULARLY (e.g., ABOUT 20 MIN./SHIFT, 3 SHIFTS/DAY FOR A TOTAL OF ABOUT 1 HOUR/DAY), BUT NOT MANDATORY FOR EVERY-SHIFT, VERSATILITY, RESPONSIVE TO TARGETS DESIRABLE b) SAME AS AUTOMATIC MODE | a) ABOUT 20 MIN., ONCE/DAY OR AS NEEDED b) NONE | a) MISSION TIME LESS SUM OF TIME FOR OTHER MODES b) NONE | a) 30-60 MIN.,/EVENT - 1 MAN EVENT: (1) FILM CHANGE EVERY 3-10 DAYS (2) SELECTED INSTRUMENT CHANGES EVERY 6-12 MONTHS b) NONE | a) UNDETERMINED (AS FAILURES OCCUR, ABOUT 1 HOUR PER EVENT) b) ASTRONAUT AVAILABILITY AND CAPABILITY, AVAILABILITY OF NEEDED TOOLS AND SPARE PARTS | | |
| II ACTIONS AND FUNCTIONS: AGENTS - a) MISSION CONTROL CENTER (MCC) b) CREW c) ON BOARD COMPUTER (OBC) d) AUTOMATIC ON BOARD SYSTEM MONITOR (AOBSM) e) PLATFORM (PLFM) | | (WARM UP TIME) MCC: AUTHORIZE DEVIATIONS FROM SCHEDULE CREW: MONITOR (1 MAN) OBC: PUT ON LINE AOBSM: ACCEPT AND COMPARE HOUSEKEEPING SIGNALS WITH STANDARD PLFM: PUT IN OPERATING POSITION | (NOMINAL OPERATING MODE) MCC: UPDATE ONBOARD EXPERIMENT CONTROL COMPUTER (TIME OFF/ON FOR SELECTED INSTRUMENTS, ENVIRONMENTAL PARAMETERS, RECORD SENSING ACCOMPLISHED) CREW: NO REGULAR ACTIVITIES OBC: CONTROL OPERATION OF INDIVIDUAL EXPERIMENTS ACCORDING TO PLANNED SCHEDULE, ENVIRONMENTAL PARAMETERS AND WEATHER INTERFERENCE FROM AUTOMATIC INDICATORS; IDENTIFY AND REPORT TO MCC DATA MISSED FOR UPDATING OF EXPERIMENT CONTROL PROGRAM AOBSM: INDICATE OUT OF CALIBRATION FROM INPUT OF HOUSE-KEEPING DATA PLFM: HOLD INSTRUMENTS IN OPERATING POSITION | (SECONDARY OPERATING MODE-PLANNED OR CONTINGENCY) MCC: AUTHORIZE; COORDINATE, DIRECT/ADVISE RE SENSING OPERATIONS; RECORD SENSING CONDUCTED CREW: MONITOR EQUIPMENT AND OPERATE (1 MAN) (SELECT TARGETS AND INSTRUMENTS) OBC: RECORD EXPERIMENT OPERATION-UPDATE EXPERIMENT CONTROL PROGRAM (IF OPERABLE) AOBSM: AS IN AUTOMATIC MODE PLFM: AS IN AUTOMATIC MODE | (UPON INDICATION OF OUT OF CALIBRATION BY AOBSM OR P.I., EVALUATION OF SAMPLE DATA OR BY ROUTINE SCHEDULE) MCC: FROM SAMPLE DATA ADVISE IF REQUIRED CREW: NOTE OUT OF CALIBRATION SIGNAL; PERFORM NECESSARY CALIBRATION ADJUSTMENTS (1 MAN) OBC: RECORD OUT OF CALIBRATION STATE AOBSM: ORIGINATE OUT-OF-CALIBRATION SIGNAL PLFM: NIL | (POWER OFF; EQUIPMENT OPERABLE) ALL:NIL | (EQUIPMENT NOT AVAILABLE FOR TAKING DATA BY REASON OF CHANGING FILM, PREVENTIVE MAINTENANCE, ROUTINE SERVICE, ALTERATIONS, CHANGE OF INSTRUMENT) MCC: AUTHORIZE AND ADVISE CREW: ACCOMPLISH (1 MAN) OBC: NONE AOBSM: NONE PLFM: NONE | (MAJOR DEACTIVATION OF FACILITY: INDIVIDUAL COMPONENTS MAY BE REPAIRED WHILE FACILITY IS IN OTHER MODES.) MCC: AUTHORIZE; ADVISE ASTRONAUT RE TECHNICAL DETAILS; CREW: ADVISE MCC AS TO NEED; CONDITIONS; MAKE REPAIRS (1 MAN) OBC: NONE AOBSM: NONE PLFM: NONE | | |
| III INFORMATION FLOW: a) INFORMATION REQUIRED b) ACTIVE LINKS c) DATA PRODUCED 1) FILM (#OF FRAMES OR FEET, WEIGHT TO BE RETURNED QUARTERLY) 2) TAPE (BIT RATES - MAX SUSTAINED, PEAK, AVERAGE; SPECIAL DUMP REQUIREMENTS) 3) REAL TIME TRANSMISSION | | a) NIL b) NONE c) NIL AND OBC | a) (1) EXPERIMENT STATUS AND OPERATIONAL CONTROL DATA (2) SCIENTIFIC DATA b) OWS - MCC c) (1) 200-300 LBS OF FILM PER QUARTER (2) MAX BIT RATE 2 x 10 ⁶ BITS/SEC AVG. BIT RATE 5 x 10 ⁵ TO 10 ⁶ BITS/SEC (3) FOR TELEMETERED SCIENTIFIC DATA; 30% WITHIN 2 HRS OF OBSERVATION, 70% WITHIN 36 HRS OF OBSERVATION, 90% WITHIN A WEEK OF OBSERVATION | a) AS IN AUTOMATIC MODE PLUS INFO AS TO TARGETS b) AS IN AUTOMATIC MODE c) AS IN AUTOMATIC MODE | a) OCCASIONAL SAMPLE DATA MAY INDICATE NEED FOR CALIBRATION b) OWS - MCC c) OCCASIONAL VOICE AND VERY LOW DIGITAL RATE | a) NIL b) NIL c) NIL | (EQUIPMENT AND EXPERIMENT STATUS) a) AUTHORIZATION FOR PERFORMING SERVICE; POSSIBLE TECHNICAL CONSULTATION b) OWS - MCC c) VOICE OR TELEPRINTER (LOW DATA RATE) | a) STATUS; TECHNICAL DATA RE REPAIR PROCEDURES b) OWS - MCC c) VOICE, TELEPRINTER, TELEVISION (SMALL TO LARGE) | | |
| IV RESOURCES REQUIRED: a) POWER b) OTHER (BESIDES ORDINARY CONSUMABLES) | | a) ~1 KW b) CRYOGENICS | a) 3 KW b) CRYOGENICS (~3 - 10 LBS/DAY, TOTAL ALL MODES) | AS IN AUTOMATIC MODE | a) ~1 KW b) CRYOGENICS | a) SMALL TO NONE b) SMALL TO NONE | a) SMALL b) SPARES, TOOLS, MANUALS | | | |
| V TRANSITIONS: a) SCHEDULED (NOMINAL) b) UNSCHEDULED (CONTINGENCIES) | | a) (1) BY OBC CONTROL TO AUTOMATIC OR BY PLAN TO MANUAL (2) BY PLAN TO CALIBRATE (3) BY PLAN TO CALIBRATE b) (1) BY OUT-OF-CALIBRATION SIGNAL FROM AOBSM TO CALIBRATE (2) BY AOBSM MALFUNCTION SIGNAL TO REPAIR (3) BY OBC CONTROL TO INACTIVE | a) (1) BY PLAN TO MANUAL (2) BY PLAN TO INACTIVE OR READY (3) BY PLAN TO CALIBRATE b) (1) BY OUT-OF-CALIBRATION SIGNAL FROM AOBSM TO CALIBRATE (2) BY MALFUNCTION SIGNAL FROM AOBSM THROUGH INACTIVE TO REPAIR | a) (1) BY PLAN TO AUTOMATIC (2) BY PLAN TO INACTIVE b) (1) BY OUT-OF-CALIBRATION SIGNAL FROM AOBSM TO CALIBRATE (2) BY MALFUNCTION SIGNAL FROM AOBSM THROUGH INACTIVE TO REPAIR | a) (1) BY PLAN TO AUTOMATIC (2) BY PLAN TO MANUAL b) (1) IF UNABLE TO CALIBRATE THROUGH IN-ACTIVE TO REPAIR (2) BY MALFUNCTION SIGNAL FROM AOBSM TO INACTIVE (REPAIR) | a) (1) BY PLAN TO READY b) (1) IF UNABLE TO COMPLETE SERVICE TO REPAIR | a) (1) UPON COMPLETION OF SERVICE TO INACTIVE (UNDER OBC CONTROL) b) (1) IF UNABLE TO COMPLETE SERVICE TO REPAIR | a) UPON COMPLETION OF REPAIR TO INACTIVE, (UNDER OBC CONTROL) | | |